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ABSTRACT

The purpose of this study was to examine pre-service elementary teachers' understanding of the concept of photosynthesis and inheritance, to explore their self-efficacy beliefs in teaching science, and to investigate the relationship between these two issues. Data were gathered through the use of misconception and science teaching efficacy beliefs instruments, and the utilization of interviews. Seventy-nine pre-service elementary teachers participated in this study and eleven pre-service teachers participated in interviews. The results showed that participants held alternative conceptions regarding photosynthesis and inheritance and have generally positive self-efficacy regarding teaching science. The results also suggested that those participants with fewer alternative conceptions regarding photosynthesis had a relatively high personal science teaching efficacy. (Contains 47 references and 7 tables.) (Author/ASK)

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PRESERVICE ELEMENTARY TEACHERS' SELF-EFFICACY BELIEFS AND THEIR CONCEPTIONS OF PHOTOSYNTHESIS AND INHERITANCE

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Abstract

The purpose of this study was to examine pre-service elementary teachers' understanding of the concepts of photosynthesis and inheritance, to explore their self-efficacy beliefs in the teaching science, and to investigate the relationship between these two issues. Data were gathered through the use of misconception and science teaching efficacy beliefs instruments, and the utilization of interviews. Seventy-nine pre-service elementary teachers participated in this study and eleven pre-service teachers participated in interviews. The results showed that participiants held alternative conceptions regarding photosynthesis and inheritance and have generally positive self-efficacy beliefs regarding science teaching. The results also suggested that those participiants with fewer alternative conceptions regarding photosynthesis had a reltively high personal science teaching efficacy.

PRESERVICE ELEMENTARY TEACHERS' SELF-EFFICACY BELIEFS AND THEIR CONCEPTIONS OF PHOTOSYNTHESIS AND INHERITANCE

Introduction

Teachers are clearly a central component for student success in learning science. However, in 1983, Feistritzer and Boyer reported that among elementary teachers, the understanding of science concepts was at low level. Previous studies have shown that elementary teachers often have negative attitudes toward science (Shrigley, 1974), science anxiety (Czerniak & Chiarelott, 1990), lack of interest for science (Tilgner, 1990), and do not have confidence in their ability to teach science (DeTure, Gregory, & Ramsey, 1990). Studies also have found that elementary teachers possess generally low level knowledge regarding the concepts, facts, and skills concerning science (Victor, 1962; Bloser & Howe, 1969; Wenner, 1993; Stevens & Wenner, 1996). A number of studies have documented that both preservice and inservice elementary teachers frequently hold alternative conceptions (or misconceptions) for a variety of science concepts and harbor misunderstandings (Schoon, 1993; Atwood & Atwood, 1996; Schoon & Boone, 1998). This often causes elementary teachers to avoid teaching science to children (Westerback, 1982; Czerniak & Chiarelott, 1990) and then less time is spent teaching science in comparision to other subjects (Westerback, 1982).

One possible reason for this situation is the preparation of prospective teachers. Generally, elementary majors complete a minimum number of science credits in their undergraduate preparation and may not take a science methods course (Greenwood & Scribner-MacLean, 1997). It has been argued that lack of such a background in science knowledge significantly contributes to hesitancy and inability to deliver effective science instruction in classroom settings. Interestingly, Stepans and McCormack (1985) found that students who completed more traditional science courses in college did not necessarily have a greater understanding of science concepts, improved attitudes to teaching science, or self-confidence in teaching science.

In a number of studies it has been argued that there are two important factors influencing elementary science teaching: teachers' level of understandings about science and their beliefs regarding science teaching (Stepans & McCormack, 1985; Wenner, 1993; Stevens & Wenner, 1996). In reaction to the importance of fostering science teaching, the present study was designed to investigate two separate constructs: self-efficacy and alternative science conceptions. By considering misconceptions the researchers hoped to evaluate one type of science understanding. Furthermore, by evaluating self-efficacy and a specific type of misconception the researchers hoped to further explore the interplay of self-efficacy and misconceptions.

Theoretical Frameworks

A. Alternative Science Conceptions

Alternative science conception can be defined as a conception which is inconsistent with currently accepted scientific views. These conceptions, constructed in an attempt to make sense of the phenomena, appear to be the ones that are most resistant to change through traditional instruction (Arnaudin & Mintzes, 1985; Duit & Treagust, 1995). Nussbaum and Novick (1982) have suggested that alternative conceptions may play a crucial role in learning by interfering with science comprehension. The person who holds alternative conceptions may have a great deal of difficulty learning new materials because their variant conceptions provide a faulty foundation for the formation of new insights (Schoon & Boone, 1998). Learners of both genders and of virtually all ages, ability levels, and cultural backgrounds subscribe to alternative conceptions. Several studies have reported on alternative science conceptions (or misconceptions) held by preservice and inservice elementary teachers (Barrass, 1984; Crawley & Arditzoglou 1988, Schoon, 1993; Atwood & Atwood 1996; Schoon & Boone, 1998). Many of the alternative conceptions that teachers harbor on science are likely to have originated partly from the texts and reference books they consult for their teaching and partly from the alternative conceptions they too had acquired as a student in high school or college (Wandersee et al., 1994). Unfortunately, if teachers retain alternative conceptions, then as classroom teachers they may reinforce the alternative conceptions currently held by student or replace them with different alternative conceptions. At best the teachers will

confuse the students or cause their students to accept different alternative conceptions for particular topics.

B. Self-efficacy:

Many studies have suggested that teacher's beliefs such as science teaching efficacy beliefs may be extremely important in motivating a teacher to teach science or causing avoidance of science teaching by a teacher (Riggs & Enochs, 1990; Ginns & Watters, 1990; Ramey-Gassert & Shroyer, 1992).

Self-efficacy beliefs as a psychological construct is rooted in a social learning theory developed by Bandura (1977, 1982, and 1986). Bandura (1977) describes two dimensions of efficacy beliefs (self-efficacy and outcome expectancy) upon which behavior is based. He defines self-efficacy beliefs as judgments of how well one can execute courses of action required to deal with prospective situations. Outcome expectancy refers to the judgements about the likely consequences of a behavior in a particular situation (Bandura, 1982). Many researchers have applied Bandura's social cognitive theory concepts to teachers (Ashton & Webb, 1986; Gibson & Dembo, 1984). Teacher efficacy refers to " a teacher's belief or conviction that he/she has the ability to influence how well students learn, even those who may be difficult or unmotivated" (Tschannen-Moran, Wolfolk-Hoy & Hoy, 1998, p.202). Bandura (1986) noted that the construct of personal efficacy is situation-specific as well as subject-specific. For example, a teacher's self-efficacy may be low in a specific subject area, such as science, and high in another, such as language arts. This may result in more time being devoted to language arts instruction, as well as more personal interest in participating in professional development activities related to this subject area.

If Bandura's theory of self-efficacy is applied to the science teaching, we might predict that teachers who believe that science learning can be influenced by effective science teaching (outcome expectancy) and who believe in their own ability to effectively teach science (self-efficacy) will more regularly and effectively teach science (Riggs, 1991).

As in Bandura's self-efficacy theory, science teaching efficacy has two dimensions: personal science teaching efficacy (PSTE), which refers to a teacher's belief in his/her ability to perform science

teaching behaviors; and science teaching outcome expectancy (STOE), which reflects a teacher belief in students' ability to learn.

Purpose of the Study

In reaction to the importance of fostering science teaching at the elementary level, this study was designed to examine the understanding of preservice elementary teachers with respect to the concepts of photosynthesis and inheritance, to explore preservice teachers' self-efficacy beliefs regarding science teaching and to investigate the relationship between these two issues. Issues related to photosynthesis are commonly taught at the elementary level, and little work has been carried out considering inheritance issues.

Data Collection

This study was based on a combination of quantitative and qualitative methods. Quantitative data for this study were collected by utilizing two instruments: (1) a misconception test involving photosynthesis and inheritance, (2) Enochs' and Riggs' (1990) Science Teaching Efficacy Belief Instrument Form B (STEBI-B). A questionnaire was also used to gather participants' demographic information.

The first instrument was constructed with multiple-choice test items. These items were designed by the researchers to identify alternative conceptions and misunderstandings of preservice elementary teachers in the area of photosynthesis and inheritance. The instrument consisted of 23 multiple-choice items. The first fifteen questions involved a variety of photosynthesis concepts (e.g. oxygen release by plants, photosynthesis, respiration, autotrophic feeding, food and energy source for plants). Photosynthesis questions were guided by consulting previously documented misconception studies (Wandersee 1985, Songer & Mintzes, 1993; Eisen & Stavy, 1988; Haslam & Treagust 1987; Amir & Tamir 1994 and Anderson et al. 1990). The second part of the instrument included 8 items related to inheritance. Inheritance questions were based on work of Kargbo et al. (1980). Items were reviewed by

subject matter experts as well as faculty members who lead science methods courses. The Science Teaching Efficacy Belief Instrument (STEBI-B) (Enochs and Riggs, 1990) developed for preservice elementary teachers was also utilized. The STEBI-B is comprised of two subscales; personal science teaching efficacy beliefs (PSTE) (13 items) and science teaching outcome expectancy (STOE) (10 items). A high logit on the first scale (PSTE), relative to other respondents, indicates a strong personal belief in one's own efficacy as a science teacher. A high logit score on the second scale (STOE) indicates high expectations with respect to the outcomes of science teaching with ones' own students. The alpha reliability coefficient for PSTE scale was found to be 0.87 and for STOE scale, it was 0.76.

Students were also asked to indicate how many science courses they had completed in college and high school. This was done to facilitate an investigation of the relationship, if any, between the number of courses completed and preservice elementary teachers' knowledge of photosynthesis and inheritance and their own science teaching efficacy beliefs.

During the fall semester of the 1998-99 academic year, seventy nine preservice elementary teachers (62 female and 13 male) who were enrolled in science methods course at Indiana University-Bloomington participated in the study. The three sections selected for this study were randomly selected from all 8 sections that semester. Students completed the instruments at the start of the semester.

Qualitative data were derived from interviews. The purpose of the interview was to further clarify and determine what preservice elementary teachers knew about photosynthesis and inheritance and to identify their self-efficacy beliefs regarding science teaching. In this study, the semi-structured interviews were conducted on one occasion and took place outside of class. After the administration of questionnaire, misconception and STEBI-B instruments, the preservice teachers for interviews were selected randomly among those who received high and low scores in these two surveys. Eleven preservice elementary teachers (9 females and 2 males) indicated their willingness to be interviewed.

Data Analysis

The stochastic Rasch model was used to evaluate survey data. One important benefit of the model is that it can provide estimates of item difficulty and person ability or attitude that are relatively invariant over different samples (Green, 1996). The Rasch model converts non-linear person and item "raw scores" to measures on a linear logit scale. It is critical to point out that parametric tests assume the use of a linear scale. Thus, the utilization of raw scores from survey instruments and tests potentially violates measurement assumptions. Wright and Linacre (1991) also mention a number of advantages of utilizing the Rasch model: (1) an evaluation is allowed when respondents do not answer every item, (2) measurement errors of survey items and respondents are reported; and (3) idiosyncratic responses of students can be easily detected. For these reasons, data presented in this study was converted to a linear logit scale then analyzed. Survey data were calibrated by using the BIGSTEPS computer program (Wright & Linacre, 1991).

Results

The result of study indicated that the pre-service elementary teachers hold alternative conceptions regarding photosynthesis and inheritance. Part of the analysis (summarized in Table 1 and 2) shows a range of alternative conceptions held by the preservice elementary teachers.

Table 1. Common alternative conceptions regarding photosynthesis and inheritance identified by questionnaire.

Alternative Conceptions	*% of the responses*
Plant's food is water	20%
Plant's food is minerals	18%
Plant's food is light	48%
Most of the food for plants comes from the water	20%
Most of the food for plants comes from the soil	49%
The energy that a bean plants uses come from soil	18%
Photosynthesis is a process in which plants take in CO_2 and change it to O_2	14%
Photosynthesis can occur in green plants all the time	20%
The soil has lost weight as the plant grew in it.	29%
If a plant and mouse were places in two different sealed containers with unlimited food, water and sunlight, both of them will die.	68%
If a plant and mouse were placed in a container with unlimited sunlight, water and food, both of them will die.	17%
Respiration is gas exchange	37%
Respiration is breathing	33%
Respiration is exhaling carbon dioxide for humans and exhaling oxygen for plants	20%
If a white male dog and black female dog has six puppies, sometimes mother, at other times the father give the color to the puppies.	39%

Table 2. Alternative conceptions about photosynthesis identified during interviews

Alternative Conceptions	Number of the subject (N=11)
Photosynthesis is a continuing process and occurs all the time.	2
Plants need darkness for the whole photosynthesis cycle	1
The most benefit to green plants when they photosynthesize is the production of energy for plant growth.	6
Plants obtain food from the soil through their roots.	6
Water, CO_2 and sunlight are the foods for the plants	6
Respiration is defined as breathing	7
Plants do not respire at all	1
Plants respire during night	3
Plants respire at the end of photosynthesis process	1
Plants respire only when they photosynthesize	2
The baby mice would have smaller tails than their ancestors when their tails had been chopped off over several generations (e.g. 200 years),	4
Variations in plants occurs very slightly	2
Identical twins result from fertilization of one egg with two different sperm	1
Some characteristics are inherited from mother and some from father	1

The responses of the participants to the requested demographic information indicated that the number of science courses completed in 4 years of high school ranged from 1 to 5 and in college by the start of their junior year ranged from 1 to 9. One-way analysis of variance was used to compare mean measures on the misconception test with the number of high school and college science courses completed by preservice elementary teachers. The results suggested no statistically significant difference between the number of alternative conceptions held by the preservice teachers as a function of science courses completed in high school and in college as a function of performance on photosythesis and inheritance sections of misconception test. The results suggest that completing a greater number of science courses in high school and in college did not significantly influence the preservice elementary teacher's number of alternative conceptions with regard to photosynthesis and inheritance.

Science Teaching Efficacy Beliefs

The preservice teachers indicated generally positive self-efficacy beliefs regarding science teaching. About 89% of the participants indicated a confidence in their ability to teach science effectively. Only 46% of the participants felt they knew the steps necessary to teach science concepts and 59% claimed to understand science concepts well enough to be effective in teaching elementary science.

All participants interviewed seemed generally willing to teach science because they thought that the science is fun and exciting. While more than half of the preservice teachers felt confident in their ability to teach science effectively, only three of them claimed to understand science concepts well enough. About half of the preservice teachers felt confident about teaching both photosynthesis and inheritance to the elementary students. Some of them, however, expressed concern regarding their background knowledge especially about photosynthesis, but they felt that they can overcome this deficiency by reviewing necessary materials prior to teaching.

Respondents also seemed generally willing to assume that student learning in the content area of science is the responsibility of the teacher. About 77 % of the participants indicated that good teaching

could overcome the inadequacy of a student's science background and 46% believed that the teacher is generally responsible for the achievement of students in science. All participiants interviwed agreed that all children are capable of learning science and effective teaching overcome inadequate student background in science. Therefore, they thought that teachers should find the right teaching strategies to teach science and to reach every child in the classroom. Many preservice teachers defined good teaching as causing students to be interested and excited about learning, making science fun and meaningful to the students, encouraging students' curiosity to learn more, considering students' interests, needs and abilities.

An analysis of variance was used to compare the mean measures of preservice teachers on the PSTE and STOE subscales with regard to the number of high school and college science courses completed. The results suggest that completing a greater number of more science courses in high school and in college did not significantly influence the preservice elementary teacher's self-efficacy, or outcome expectancy. However, analysis of interview data suggests that the science methods course and completed field experiences had a positive impact on a number of subject's personal science teaching efficacy.

Alternative Conceptions and Science Teaching Efficacy

One purpose of this study was to consider what, if any, relationship existed between the holding of alternative conceptions with regard to photosynthesis and inheritance, and science teaching efficacy. This was done by comparing the number of alternative conceptions by preservice elementary teachers with the personal science teaching efficacy (PSTE) and science teaching outcome expectancy (STOE) subscales of the STEBI-B instrument. A *t*-test was conducted to compare PSTE measures and STOE measures with the number of alternative conceptions held. In order to carry out this comparison, mean attitudinal measures for preservice teachers' for PSTE and STOE were computed.

Table 3 displays the PSTE measure of surveyed preservice elementary teachers as a function of the alternative conceptions held regarding photosynthesis. Similarly, table 4 displays the PSTE measure of surveyed preservice elementary teachers as a function of alternative conception held regarding

inheritance. Recall that a more positive PSTE measure suggests that a more positive view with regard to personal science teaching efficacy. Review of table 3 suggests that those participants with a relatively low number (8 or less) of photosynthesis alternative conceptions seemed to have more positive PSTE beliefs themselves. However, no clear pattern is present when the inheritance portion (Table 4) of the test is reviewed.

T- tests were run to compare the PSTE measures to the number of alternative conceptions with regard to photosynthesis and inheritance identified. The t-test results showed that PSTE means of those students who selected 8 or less of the photosynthesis alternative conceptions was significantly higher than PSTE means of those who selected 9 or more of the photosynthesis alternative conceptions (Table 5). Interestingly, a comparision of PSTE means and number of inheritance alternative conceptions did not reveal any clear statistically significant pattern.

Table 3. PSTE measure by number of photosynthesis alternative conceptions held by preservice elementary teachers

Number of Alternative Conceptions	N	PSTE Mean Measure (logits)	Std Deviation (logits)
5	2	+2.50	1.80
6	5	+1.85	1.95
7	12	+2.59	1.68
8	16	+2.15	1.47
9	18	+1.47	1.16
10	18	+1.16	0.99
11	6	+1.47	0.75
13	2	+.46	0.72

Table 4. PSTE measure by number of inheritance alternative conceptions held by preservice elementary teachers

Number of Alternative Conceptions	N	PSTE Mean Measure (logits)	Std Deviation (logits)
0	1	-0.33	-
1	11	+2.40	1.54
2	38	+1.70	1.29
3	21	+1.88	1.49
4	5	+0.99	0.66
5	2	+0.98	0.77
6	1	-0.05	-

Table 5. T-test comparing PSTE measures of preservice elementary teachers as a function of low and high photosynthesis alternative conceptions

	N	Mean Measure	SD	T
Low number of Photosynthesis Alternative Conceptions (8 or less) Held	35	2.27	1.57	3.17*
High number of Photosynthesis Alternative Conceptions (9 or more) Held	44	1.30	1.02	

* $p < 0.05$

Table 6 displays the STOE measure of preservice teachers as a function of photosynthesis alternative conceptions. Similarly, table 7 displays the STOE measure of preservice teachers as a function of inheritance alternative conceptions. No clear pattern is suggested in these data (Tables 6 and 7). Statistical analysis also suggested no clear relationship between STOE items and number of alternative conceptions held regarding photosythesis and inheritance.

Table 6. STOE measure by number of photosynthesis alternative conceptions held by preservice elementary teachers

Number of Alternative Conceptions	N	STOE Mean Measures	Std Deviation
5	2	+1	0.71
6	5	+1.02	1.49
7	12	+0.78	0.62
8	16	+0.99	0.95
9	18	+1.15	0.57
10	18	+0.86	1.07
11	6	+1.24	1.01
13	2	+1.22	1.34

Table 7. STOE measure by number of inheritance alternative conceptions held by preservice elementary teachers

Number of Alternative Conceptions	N	STOE Mean Measures	Std Deviation
0	1	+0.38	-
1	11	+0.95	1.03
2	38	+0.97	0.69
3	21	+1.09	1.20
4	5	+1.31	0.46
5	2	+0.22	0.56
6	1	+0.88	-

Conclusions and Discussion

Several studies have reported on science misconceptions held by pre-service and inservice elementary teachers (Barrass, 1984; Enochs & Gabel, 1984; Stepans, Dyche & Beiswnger 1988, Crawley & Arditzoglou 1988, Schoon, 1993; Atwood & Atwood 1996; Schoon & Boone, 1998). Data collected in this study confirms that preservice elementary teachers hold alternative conceptions regarding photosynthesis and inheritance.

Results suggest that the concept of photosynthesis and inheritance were not well understood by preservice elementary teachers. Many participants perceive of photosynthesis and respiration as being only gas exchange. Studies by Wandersee (1985) and Songer and Mintzes (1993) suggested that students

of all ages have difficulty understanding the role of carbon dioxide as the primary source of plant biomass. Similarly, in this study, the preservice elementary teachers demonstrated that they were not aware that plants absorb CO_2 and water to produce organic materials which are being used in respiration. These students seem to understand the dependence of animals on plants as a primary source of oxygen. They fail, however, to recognize that plants respire and thereby produce enough carbon dioxide to survive independently of animals. Many preservice teachers also subscribe to the notion that plants obtain their food from the soil. These preservice elementary teachers seem to regard plant food as anything taken in by the plant from its surroundings, and they ignore internal synthesizing. This is perhaps understandable, as everyday language suggests that food is something solid that is taken in from the outside. The misconception instrument suggests that the preservice elementary teachers exhibited fewer misconceptions with regard to the concept of inheritance. However, qualitative data analysis suggested that there was confusion about long-term acquired changes within an organism's lifetime; a few preservice elementary teachers believe that acquired characteristics can be inherited over several generations. Similar results were found by the study of Engel Clough and Wood-Robinson (1985) with their interview of upper elementary children. This might indicate that preservice teachers hold alternative conceptions regarding photosynthesis and inheritance which are similar to the children.

The concepts of photosynthesis and inheritance are often a part of science curriclum at the elementary grades, and these topics are presented over and over in a student's studies. But these teachers demonstrate a significant number of misconception with regard to these two topics. Unfortunatley these teahers with alternative conceptions about photosythesis and inheritance are not likely to be able to develop scientifically accurate concepts in their students. If teachers are to effectively teach these concepts, preservice teachers need to become aware of their own alternative conceptions as well as acquaint themselves with typical misconceptions held by children.

In exploring the relationship that might exist between the number of science courses completed in high school and college and the number of alternative conceptions, analysis of this study data failed to show any significant relationship between these variables. Neither the number of high school science

courses nor the number of college science courses completed were associated with preservice teachers' number of alternative conceptions regarding photosynthesis and inheritance. Steven & Wenner (1996) suggested that the completing of traditional college science courses does not always affect students' understanding of science. It is clear that courses as described by McDevitt et al. (1993), should be taught using methods that relate concepts, avoid lecturing and memorizing, build upon what students already know, and pay attention to development of science concepts and overcome alternative conceptions.

It seems that the successful implementation of science education programs in elementary schools may depend on teachers' self-efficacy beliefs, that is, their personal beliefs about their ability to teach science and their ability to produce positive outcomes in science for children. The results from the self-efficacy survey and individual interviews showed the generally positive efficacy beliefs expressed by the most of the preservice elementary teachers regarding their ability to teach elementary science. About half of the preservice teachers interviewed felt confident about teaching both photosynthesis and inheritance to the elementary level students. Some of them, however, expressed concern regarding their background knowledge, especially about photosynthesis, but they thought that they could overcome this deficiency by reviewing necessary materials before teaching. They seem to be optimistic and believe that they will indeed be effective elementary science teachers in the future. Similar results were found by Stevens and Wenner (1996) in their study suggesting that preservice teachers with low knowledge bases were relatively optimistic about their abilities to teach science.

Furthermore, it does appear that these prospective teachers are willing to assume the responsibility for children's science achievement because they believe that student learning in the content areas of science is the responsibility of the teacher. They agreed that all children are capable of learning science and effective teaching overcome inadequate student background in science. Therefore, they suggested that teachers should find the right teaching strategies to teach science to the children and to reach every child in the classroom.

A number of studies recommended that preservice elementary teachers should undertake more science content and methods courses (Tilgner, 1990; Enochs & Riggs, 1990). However, Wenner (1993)

reported that an insignificant relationship between the number of high school and college science courses completed and teachers' confidence regarding science teaching. Conversely, Stepans and McCormack (1985) found a negative relationship. Data of this study suggests that science courses completed in high school and college do not appear to have influenced subjects' self-efficacy beliefs regarding science teaching. This suggests that science teacher educators should structure existing (and any new) courses to include experiences that make students aware of, and able to confront, their existing beliefs about their ability to teach science. However, analysis of interview data suggests that the science methods course and completed field experiences had a positive impact on a number of subject's personal science teaching efficacy. It appeared that most preservice teachers interviewed had gained positive perceptions about teaching science from their science methods class. This finding is consistent with the previous research. Huniker and Madison (1997) found that the science methods courses consistently had a positive influence on the preservice elementary teachers' beliefs in their ability to teach science effectively and their outcome expectancy with regards to science. The data in this study also provide evidence which supports the suggestion that self-efficacy beliefs can be enhanced by a well structured science methods course which is activity based and hands-on. It has also been suggested by Ramey-Gassert et al. (1996) that preservice teachers need to learn in a setting with an open-ended inquiry, hands-on investigative approach to science learning.

In exploring the relationship that might exist between the number of alternative conceptions regarding photosynthesis held and personal science teaching efficacy analysis, the results of the analysis showed that those with the lowest number of alternative conception regarding photosynthesis (8 or less) had relatively high personal science teaching efficacy. Although Stephans and McCormack (1985), Wenner (1993) and Stevens and Wenner (1996) found a negative relationships between science knowledge and science teaching efficacy, this finding is consistent with Schoon and Boone's study which found those with high performance on a science concept test had a positive personal science teaching efficacy beliefs. The finding of this study supports a conclusion that the holding of alternative conceptions regarding photosynthesis is associated with those persons of low personal science teaching efficacy.

Holding of alternative conceptions may interfere with preservice elementary teachers' learning process, which may influence their broader understanding of the concept of photosynthesis. This could result in a less confident view of their own abilities to teach this particular concept—photosynthesis. A possible explanation for the observed relationship between number of alternative conceptions and these teacher's confidence in his/her ability to teach science was offered by Schoon and Boone (1998), who found the holding of certain specific alternative conceptions may function as a barrier to the learning of more science, learning about science, and feeling good about one's own abilities to teach science. Most people are comfortable with their own alternative conceptions, because they believe that what they know is true. Yet, some specific alternative conceptions may act as critical barrier to the learning of more science.

Implications and Recommendations

In order to provide quality science education, preservice elementary teachers will have to become better prepared to teach science. As a part of science methods courses, preservice elementary teachers need to be made aware that misconceptions in science exist and that they may harbor some of these misconceptions.

Effective science preparation classes need to be developed that introduce preservice teachers to their own misconceptions and misconceptions commonly held by students. As Ausebel (1968) stated that "single most important factor influencing learning is what the learner already knows." Instructors must take into account that what is already known by their students and help them to build upon what they already know. Science courses should be based on less lecturing and less memorization and more hands-on and minds-on opportunities.

Developing self-efficacy beliefs among preservice elementary teachers for teaching science is of paramount importance. This can be accomplished by well-planed science methods class which should be activity based and hands-on. Preservice teachers need to learn in an inviting, collegial, and noncompetitive atmosphere.

These implications for enhancing science teaching efficacy and a sound background content knowledge are especially important to prepare elementary level teachers. They will help in having a greater chance that can make a positive difference in classroom science teaching.

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